ON THE EFFECT OF ELECTRICAL FIELD ON INDIAN CARPS IN CAPTIVITY

G. N. MITRA
Ministry of Food, Agriculture, C. D. and Co-operation
Govt. of India, Krishibhavan, New Delhi
AND
K. P. BISWAS*
Pilot Power Fishing in Sea, Paradeep, Cuttack, Orissa.

Threshold current densities required for narcosis of fish in captivity differed in different species. Increased temperature of the water had greater effect on the fishes while changes of pH had no appreciable effect on narcosis in the fishes. Impulse currents of 50 V were found to have better effect on the fishes than continuous current of 180–220 V.

INTRODUCTION

The reaction of different fishes to various densities of A/C and D/C have been studied in Germany and U. S. A. in order to evolve suitable electrical fishing gear. Experiments in the University of Hawaii showed the greater effect of interrupted D/C compared to A/C and continuous D/C, the larger fish being affected to a greater extent. Groody *et al.* (1952) found pulsating D/C producing directional movement at a current density of 0 to 80 mA per 6.45 cm^2 depending on the size of the fish. Kuroki *et al.* (1953) observed that no influence of the frequency upon electrifying voltage in *Carassius auratus* could be detected within 10 to 150 rhythms per second. They also reported that the mean value of current intensity increased with frequency. Dickson (1954) found pulsed D/C with a duration of 2 to 3 milliseconds at the rate of 15 cycles per second to be effective in sea water. Meyer-Warrden (1957) indicated the possibilities of utilising electrical energy in fisheries. Mitra and Sen Gupta (1957) while studying the effect of A/C on *Catla catla* and *Ophiocephalus punctatus* at different voltages, temperatures, pH and distances between electrodes observed that large fish were more prone to electric shock. Higher temperatures increased the intensity of the shock. The present experiments were conducted to study the effects of A/C and D/C on *Labeo rohita* (Ham), *Cirrhina mrigala* (Ham), *Labeo calbasu* (Ham), *Cirrhina reba* (Ham) and *Cyprinus carpio* (Lin).

* Present address: Directorate of Fisheries, Cuttack-7, Orissa.

Materials and methods

The apparatus used consisted of an insulated metal cistern of 273 cm x 121 cm x 84 cm size, wider at the top (270 cm x 121 cm) than the bottom (272 cm x 92 cm). The cistern was painted and insulated by keeping on rubber tyres. The switch board consisted of one volt meter, one ammeter and a rheostat to control the voltage. The first set of electrodes were two paddle shaped wooden frames of 30.5 cm x 17.5 cm with wooden handles. A copper net strip of 20 guage was attached vertically to the frames which were kept parallel to each other. The second set of electrodes were rectangular copper plates of 0.5 mm thickness and 15.5 cm x 8 5 cm size attached to wooden handles. The cistern was filled with water to a depth of one metre at pH 7.6 to 7.8. The electrodes were inserted in the cistern one at each end along the middle line keeping them vertical, care being taken to see that the electrodes did not come into direct contact with the cistern The distance between the electrodes were maintained at 250 cm in the case of copper net electrodes and 85 cm in the case of copper plate electrodes. 220 V D/C and 220 V A/C of 50 c/s were used as sources of power supply.

The fishes were collected from tanks and kept in aquaria for 24 hours for acclimatisation, after which they were taken in a cage of hand net and immersed in the water at different distances from the electrodes. The times of narcosis and recovery of the fish were recorded with the help of a stop watch. The current density at the particular place where the fish was immersed in the cage was calculated in μA per mm^2 between electrodes and was expressed as δ. One fish was used for the test only once to avoid the fatigue factor. Experiments were done at different temperatures under controlled conditions.

Results and discussion

An input voltage of 40 and current density of 0.397 δ produced narcosis in fish, 77 to 140 mm length at temperature of 24.5°C (table I). The effect was more marked at a temperature of 27°C (Table II). There was no indication that larger fish were affected more intensely. At a voltage of 180, current densities of 0.999 and 1.998δ had no effect on fish of 135 to 175 mm length at 23°C, time of exposure being 10 to 30 seconds. Narcosis was produced in 4 to 17 seconds, 2.3 to 7 seconds and 2 5 to 4 seconds at current

TABLE I BEHAVIOUR OF *L. rohita* IN D/C FIELD AT DIFFERENT CURRENT DENSITIES

Electrode: Copper plate 15.5 cm x 8.5 cm
Distance between electrodes: 85 cm.
Voltage input: 40
Water: Temp: 24.5°C, pH: 7.6

Size in mm	Period of shock in seconds for narcosis	Period of recovery in seconds
	Current density .397 δ	
72	60	No effect
77	60	-do-
122	17	.5
124	29	-do-
125	28	-do-
-do-	30	-do-
-do-	18	-do-
126	30	-do-
127	25	-do-
129	23	-do-
130	21	-do-
140	41	-do-
	Currrent density .595 δ	
70	13	-do-
71	12	-do-
74	23	-do-
75	15	-do-
-do-	27	-do-
85	31	-do-
86	32	-do-
90	15	-do-

TABLE II BEHAVIOUR OF *L. rohita* AT DIFFERENT TEMPERATURES IN D/C FIELD

Electrodes: Copper plate 15.5 cm x 8.5 cm.
Distance between electrodes: 85 cm.
Voltage input: 40. pH of water: 7.6

Size in mm	Period of shock in seconds for narcosis	Period of recovery in seconds
	Temp. of water: 24.5°C	
72	60	No effect
77	-do-	-do-
122	17	.5
124	29	-do-
125	28	-do-
-do-	30	-do-
-do-	18	-do-
126	30	-do-
127	25	-do-
129	23	-do-
130	21	-do-
140	40	-do-
	Temp. of water: 27°C	
51	35	.2
65	12	.5
75	52	.2
76	15.5	.2
78	12	.5
119	8	1.5
121	44	26
122	53	41
125	41	.5
-do-	20	-do-
-do-	61	-do-
-do-	39	1
126	30	12
130	42.5	1
132	13	.5

densities of 2.997δ, 4.995δ and 7.992δ respectively (Table III). Here again there was no noticeable difference in the intensity of shock on the different sizes, nor in the period of recovery under different densities of current. It was however seen that while current density of 1.998δ produced no effect at 23°C, it produced severe shock

TABLE III EFFECT OF DIFFERENT CURRENT DENSITIES AND WATER TEMP. ON PERIODS OF NARCOSIS AND RECOVERY IN FISH IN D/C FIELD

Electrodes: Copper wire net 30.5cm x 17.5cm.
Distance between electrodes: 250 cm.
Water temp: 23°C, pH: 7.8.
Voltage input: 180 D/C.

Size in mm	Period of shock for narcosis in seconds	Period of recovery in seconds
	Current density: 2.997δ	
120	17	1
140	13	4
-do-	25	1
170	16	2
180	4	1.2
	Current density: 4.995δ	
108	7	1
130	2.3	3
135	4	.5
140	3	2.5
145	3.8	1
	Current density: 7.992δ	
140	4	1.2
141	3	-do-
-do-	2.5	3.5
168	4	2
180	3	-do-
	Current density: 1.998δ Water temp: 25.5°C	
135	23	68.4
137	18	88
146	18.7	21
148	27.2	98
155	20	6.3

at 25.5°C (Table III). The shocks were considerably intense when the pH was changed from 7.6 to 7.8 (Table IV).

In the case of *C. mrigala* upto a current density of 1.998δ there was no effect on fish ranging from 100 to 153 mm length, time of exposure being 15 to 21 seconds.

TABLE IV BEHAVIOUR OF *L. rohita* AT DIFFERENT pH IN D/C FIELD.

Electrode: Copper wire net
30.5 cm x 17.5 cm.
Distance between electrods: 250 cm.
Water temp: 25.5°C,
Voltage input: 180 D/C.
Current density: 1.998δ

Size in mm	Period of shock in seconds for narcosis	Period of recovery in seconds.
	pH: 7.6	
151	36.4	8.3
152	9.8	1.3
153	3.5	1
154	61	2.1
154	10.5	1
185	9	1.2
	pH: 7.8	
135	23	68.4
137	18	88
146	18.7	21
148	27.2	98
155	20	6.3

TABLE V BEHAVIOUR OF *C. mrigala* IN DIFFERENT CURRENT DENSITIES IN D/C FIELD

Electrode: Copper wire net
30.5 cm x 17.5 cm.
Distance between electrodes: 250 cm.
Water Temp. 23°C, pH: 7.8
Voltage input: 180 D/C

Size in mm	Period of shock in seconds for narcosis	Period of recovery in sec.
	Current density. 2.997 δ	
100	40	No effect
105	45	-do-
130	35	1.2
153	6.5	77
	Current density: 4.995 δ	
103	30	No effect
105	6	1.5
107	4.5	1
120	8.5	8
135	5.5	1
136	5.6	3.2
	Current density: 7.992 δ	
120	12	1.5
-do-	26.6	1.2
133	6	1.6

But 2.997, 4.995 and 7.992δ produced narcosis which was generally more severe in the case of larger fish. Densities of 2.997 and 4.995δ had no effect on fish upto 105 and 103 mm respectively (Table V). An increase of temperature from 23 to 24°C produced narcosis in fish above 51 mm and the larger fish were narcotised by shocks of less duration (Table VI). Using A/C with an input of 220 V at 27.5°C and pH 7.8, a current density of 0.4δ was sufficient to produce narcosis and there was no marked difference when the current density was raised to 1.998δ (Table VII). In a comparative test at pH 7.8, temperature 25.5°C, input voltage 180 D/C and current density of 1.998δ, it was found that *C. reba, L. calbasu* and *L. rohita* were more readily affected, while *C. mrigala C. carpio* did not respond to the shock (Table VIII). In another comparative test using D/C pulsating 50 V, 8 pulses per second, D/C 180 V continuous, A/C interrupted 50V, 8 pulses per second and A/C 220V continuous, the current density was maintained at 2.4δ. It was seen that the A/C interrupted was most effective as regards period required for shock. D/C, 50V, 8 pulses per second ranked next while continuous D/C of 180V and A/C of 220V produced shocks of severe intensity on fishes over 130 mm length (Table IX).

Threshold current densities are required for effective narcosis of fish in captivity. If the fishes are left free in the electric field, they show directional movement (Groody *et al, loc. cit*) with an increase in current density. It has been

TABLE VI BEHAVIOUR OF *L. rohita* AT DIFFERENT TEMPERATURES IN D/C FIELD

Electrode: Copper wire net
30.5 cm x 17.5 cm.
Distance between electrodes: 250 cm
pH of water: 7.8, Voltage input: 180 D/C
Current density: 1.998 δ

Size in mm.	Period of shock in seconds for narcosis	Period of recovery in seconds
	Water temp: 23°C	
100	40	No effect
105	45	-do-
130	35	1.2
153	6.5	77
	Water temp: 24°C	
45	45	No effect
50	-do-	-do-
51	47.5	14.5
100	14	1.5
131	11	1
150	3.8	.7
152	2.5	1.2

observed that a current density of 2.997δ is required to narcotise *L. rohita* of 120 to 180 mm and *C. mrigala* of 130 to 153 mm, while a current denity from 0 to a maximum of 80 mA/6.45cm² are most effective in producing directional movement in Pacific sardines. Norman (1954) observed that the optimal average current density varied inversely with the size of the fish in producing forced directional swimming. The periods of shock required for narcosis decreased with the increase in current density. Cattley (1955) observed that the recovery rate of the fish depended on the exposure which does not agree with our observation. Intense shocks were observed at increased temperatures which confirmed the findings of Mitra and Sen Gupta *(loc. cit)*. However these workers did not find any effect due to change in pH while we observed intense shock on increasing the pH.

TABLE VII BEHAVIOUR OF *L. rohita* IN DIFFERENT CURRENT DENSITIES IN A/C FIELD

Electrode: Copper wire net
30.5 cm x 17.5 cm.
Distance between electrodes: 250 cm
Water temp: 27.5°C, pH: 7.8
Voltage input: 220 A/C

Size in mm	Period of shock in seconds for narcosis	Period of recovery in sec.
	Current density: 0.4 δ	
126	10	6
132	9	2
139	5	4
140	6	1.5
141	8 5	2.5
148	7.8	3
150	3.5	1
154	10 5	2
173	2.2	4.2
176	6	2.4
186	4	1.5
	Curreut density: 0.999 δ	
125	12	3.2
149	5.1	12.1
155	5	19.8
173	2.2	4.2
182	4.5	12.5
253	6	14
	Current density: 1 998 δ	
141	12	.5
149	7	1.8
151	3	1
154	4.5	1.5
158	6	1.3
160	3.5	2
170	2.8	54
175	-do-	4.5
182	4.8	1.75

TABLE VIII COMPARATIVE EFFECT OF DIFFERENT SPECIES IN D/C FIELD

Electrodes: Copper wire net 30.5 cm x 17.5 cm
Distance between electrodes: 250 cm.
Water temp: 25.5°C, pH: 7.8
Voltage input: 180 D/C, Current density: 1.998δ

Size of the	L rohita		C. mrigala		L. calbasu		C. carpio		C. reba	
fish in mm	I	II	I	II	I	II	I	II	I	II
105	—	—	18	No effect	—	—	--	No effect	6.5	2.2
110	—	—	-do-	-do-	24	1	35	-do-	7	4
115	—	—	38	-do-	—	—	—	—	—	—
120	—	—	18	-do-	—	—	35	No effect	19	150
125	—	—	-do-	-do-	13.5	62	34	-do-	12.2	77
130	—	—	-do-	-do-	5	2.5	—	—	—	—
135	23	68.4	15	-do-	—	—	34	No effect	—	—
145	18.7	21	—	—	—	—	-do-	-do-	—	—
150	36.4	8.3	—	—	—	—	—	—	5.2	4.1
155	20	6.3	21	No effect	5.2	2.5	60	No eflect	—	—

I = Period of shock for narcosis (seconds)
II = Period of recovery (seconds)

TABLE IX BEHAVIOUR OF *L. rohita* IN DIFFERENT TYPES OF CURRENT

Electrodes: Copper wire net 30.5 cm x 17.5 cm
Distance between electrodes: 250 cm.
pH of water: 7.8, current density: 2.4δ

Size in mm	D. C. pulsating-8 pulses/sec. 50 volts		D. C. continuous 180 volts		A. C. interepted-8 pules per sec 50 volts		A. C. continuous 50 c/s 220 volts	
	I	II	I	II	I	II	I	II
120	23.2	2.3	—	—	6.2	1.5	—	—
125	—	—	—	—	16	-do-	—	—
130	15.3	1.5	—	—	8.5	1.3	—	—
135	24	1 2	23	5	7.5	1.8	3.4	1.2
140	23	2	—	—	19	-do-	12	.5
145	46	327.5	18.7	21	5	7	—	—
150	92	2.5	36.4	8.3	—	—	2.2	1
155	—	—	20	6.3	12	1	5	1.3
160	33	1	35	No effect	10	3	3.4	1

I = Period of shock for narcosis (seconds)
II = Period of recovery (seconds)

C. reba, L. calbasu and *L. rohita* were affected by a current density of 1.998δ while *C. mrigala* and *C. carpio* did not respond at that current density. This shows a specific selectivity of threshold current density for narcosis of the fishes. It was also shown by Halsband (1955) that this varied with species of fish. Interrupted current of 50 V was more effective than continuous current of 180 to 220V,

possibly due to the accommodation of the nerves of the fish towards electrical stimulation and the gradual decrease in current density due to local action and polarisation occurring in continuous current. Hosl (1955) observed greater physiological effect on fish by impulse current. We found impulse current of 50 V with 8 impulses per second to be superior to continuous current of 180 to 220V.

Conclusion

A threhold current density is required for narcosis of fishes of different size groups. Increase in temperature of the water decreased the threshold current densities as well as time of exposure required for narcosis. The intensity of shock increased with increase of pH of the medium. There was specific selectivity of threshold current densities for narcotising fishes. Pulsating interrupted current was superior to continuous D/C or A/C as far as narcosis of fish was concerned.

References

Cattley J. G. 1955. *World Fishing, 4 (3),* 125–127.

Dickson W. 1954. *Ibid, 3 (4),* 148–151.

Groody T. A. S., Loukashin & Grant N. 1952. *Proc. California Acad. Sci., 27 (8),* 311–323.

Halsband E. 1958. *Archiv f. Fischereiwiss., 6 (3, 4)* 218–222.

Hosl A. 1955. *Der Fischwirt., 5 (8),* 235.

Kuroki T, Morita T & Fukudome T. 1953. *Bull. Jap. Soc. Sci. Fish., 8 (3),* 359.

Mitra G. N. & Sen Gupta S. K. 1957. *Fish. Technol., 4 (1),* 10.